Claims

What is claimed is:

1. A signal processing method comprising the steps of:

processing a signal in a signal processing device configured to implement a transform for producing a desired transformed output signal; and

updating the transform during the processing step based on received data associated with the signal being processed, so as to track a basis associated with the transform;

wherein the transform is represented in a reduced-parameter form and the updating step is implemented using computations involving the reduced-parameter form.

2. The method of claim 1 wherein the transform comprises a Karhunen-Loève transform.

3. The method of claim 1 wherein the reduced-parameter form for an N x N transform comprises fewer than N^2 parameters.

4. The method of claim 1 wherein an adaptation of the transform is represented directly as one or more changes in the reduced-parameter form.

5. The method of claim 1 wherein the reduced-parameter form comprises a Givens parameterized form.

6. The method of claim 5 wherein the updating step utilizes multiplications of Givens parameterized matrices computed in parametric form.

7. The method of claim 1 wherein the reduced-parameter form comprises a Householder form.

8. The method of claim 1 wherein the updating step avoids the need for an explicit eigendecomposition operation in implementing the transform.

9. The method of claim 1 wherein the updating step makes adjustments in the transform so as to minimize a negative gradient of a pairwise energy compaction property of the transform.

10. The method of claim 9 wherein the negative gradient minimization is locally convergent in mean for a specified step size.

11. The method of claim 9 wherein the adjustment for a kth parameter of the transform associated with a particular one of a plurality of Givens rotations is given by $\theta_k = \mu 2 y_{i_k} y_{j_k}$, where μ is the step size of the gradient algorithm, y_i and y_j are designated pairs of elements of a matrix $Y = TXT^T$, T is a matrix representing the transform, and X is a matrix representing elements of the signal being processed.

12. The method of claim 1 wherein the transform comprises a backward adaptive transform and the updating step is driven by quantized data.

13. An apparatus comprising:

a signal processing device configured to implement a transform for processing a signal so as to produce a desired transformed output signal, the device further being operative to implement a process for updating the transform while processing the signal, in accordance with received data associated with the signal, wherein the transform is represented in a reduced-parameter form and the updating process is implemented using computations involving the reduced-parameter form.

14. The apparatus of claim 13 wherein the transform comprises a Karhunen-Loève transform.

15. The apparatus of claim 13 wherein the reduced-parameter form for an N x N transform comprises fewer than N^2 parameters.

16. The apparatus of claim 13 wherein an adaptation of the transform is represented directly as one or more changes in the reduced-parameter form.

17. The apparatus of claim 13 wherein the reduced-parameter form comprises a Givens parameterized form.

18. The method of claim 17 wherein the updating process utilizes multiplications of Givens parameterized matrices computed in parametric form.

19. The apparatus of claim 13 wherein the reduced-parameter form comprises a Householder form.

20. The apparatus of claim 13 wherein the updating process avoids the need for an explicit eigendecomposition operation in implementing the transform.

21. The apparatus of claim 13 wherein the updating process makes adjustments in the transform so as to minimize a negative gradient of a pairwise energy compaction property of the transform.

22. The apparatus of claim 21 wherein the negative gradient minimization is locally convergent in mean for a specified step size.

23. The apparatus of claim 21 wherein the adjustment for a *k*th parameter of the transform associated with a particular one of a plurality of Givens rotations is given by $\theta_k = \mu 2 y_{i_k} y_{j_k}$, where μ is the step size of the gradient algorithm, y_i and y_j are designated pairs of elements of a matrix $Y = TXT^T$, T is a matrix representing the transform, and X is a matrix representing elements of the signal being processed.

24. The apparatus of claim 13 wherein the transform comprises a backward adaptive transform and the updating step is driven by quantized data.

25. A machine-readable medium for storing one or more software programs for use in processing a signal in a signal processing device configured to implement a transform for producing a desired transformed output signal, the one or more software programs when executed implementing the step of:

updating the transform based on received data associated with the signal being processed, so as to track a basis associated with the transform;

wherein the transform is represented in a reduced-parameter form and the updating step is implemented using computations involving the reduced-parameter form.

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Declaration and Power of Attorney

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHODS AND APPARATUS FOR ADAPTIVE SIGNAL PROCESSING INVOLVING A KARHUNEN-LOÈVE BASIS** the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

I acknowledge the duty to disclose all information known to me which is material to patentability as defined in Title 37, Code of Federal Regulations, 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

None

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

None

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorney(s) with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby appoint the attorney(s) on ATTACHMENT A as associate attorney(s) in the aforementioned application, with full power solely to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected with the prosecution of said application. No other powers are granted to such associate attorney(s) and such associate attorney(s) are specifically denied any power of substitution or revocation.

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ATTACHMENT A

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